Effect of reproductive disorders and parity on repeat breeder status and culling of dairy cows in Quebec

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Abstract

This study quantified the effect of peripartum reproductive disorders and parity on repeat breeder status and involuntary culling of dairy cows. Reproductive data of 418 383 lactations were taken from a computerized databank of health records for dairy cows. A logistic regression model was used with dystocia, retained placenta (RP), metritis complex, and parity as fixed effect risk factors and herd entered as the random effect. Of the peripartum problems studied, dystocia had the greatest effect on future fertility. Dystocia increased the odds of a cow being a repeat breeder by 44% [odds ratio (OR): 1.44; confidence interval (CI): 1.37 to 1.51]. Compared to first-parity cows, cows in second, third, and fourth parities had significantly higher odds of being a repeat breeder: 18% (OR: 1.18; CI: 1.16 to 1.20); 24% (OR: 1.24; CI: 1.21 to 1.26); and 42% (OR: 1.42; CI: 1.39 to 1.45), respectively. The odds for second-, third-, or fourth-parity repeat breeders being culled were 24% (OR: 1.24; CI: 1.20 to 1.28); 39% (OR: 1.39; CI: 1.35 to 1.43); and 67% (OR: 1.67; CI: 1.62 to 1.71) respectively, while peripartum reproductive problems had less of an effect.

Résumé

L'objectif de cette étude est de quantifier l'effet des problèmes reproducteurs peripartum et du nombre de lactations sur la catégorisation «Repeat Breeder» ainsi que la décision de réforme conditionnelle à ce statut. Une banque de données informatisées répertoriant 418 383 lactations a été analysée en utilisant des modèles de régression logistique. L'étude démontre que la dystocie est la condition ayant le plus d'effets sur la fertilité future. Une vache avec un historique de dystocie a 44 % (RC : 1,44, IC : 1,37–1,51) plus de chances d'être catégorisée RB. La deuxième, troisième et quatrième lactation ont 18 % (RC : 1,18, IC : 1,16–1,20), 24 % (RC : 1,24, IC : 1,21–1,26) et 42 % (RC : 1,42, IC : 1,39–1,45) plus de chances de devenir RB versus la première lactation. Une RB de deuxième, troisième et quatrième lactation augmente de 24 % (RC : 1,24, IC : 1,20–1,28), 39 % (RC : 1,39, IC : 1,35–1,43) et 67 % (RC : 1,67, IC : 1,62–1,71) le risque de réforme par rapport à une vache primipare, tandis que l'effet de l'historique des problèmes peripartum s'estompe dans ce dernier modèle.

(Traduit par les auteurs)

Introduction

The fertility of dairy herds has declined throughout the world in recent years (1–3). Quebec's dairy herds are no exception. The reasons for this decline include changes in monitoring fertility, increased milk production, intensified genetic selection, and the health — particularly the uterine health — of cows (3).

Cows that fail to conceive after several attempts are a problem for the producer. Repeat breeder (RB) cows fall into this category. These are cows that cycle normally and have no clinical abnormalities after a minimum of 3 inseminations (4). The economic losses associated with RB cows are considerable: increased veterinary expenses and insemination costs, reduced productivity, and losses due to involuntary culling.

Reproductive problems have been the primary cause of culling in animal husbandry for many years (5,6). Unlike in the 1950s, poor reproductive performance has a much greater influence today on the decision to cull than weak dairy production (6). The longer a cow takes to conceive, the greater the odds are that it will be culled. Involuntary culling reduces a herd's profitability because it is not associated with dairy production.

Diseases of the reproductive system cause reductions in fertility (5–8). The magnitude of their effect on reproductive performance depends on the severity of the condition, the timing of the condition, and herd management practices. The diagnosis of uterine problems is complicated by the large number of such problems and the many variations in their clinical presentation. One way to simplify the classification of conditions is to consider clinical metritis, endometritis, and pyometritis as variables of the same disease and combine them into 1 diagnostic category: metritis complex (9,10). Dystocia, retained placenta (RP), metritis, and endometritis result from mechanical and/or functional damage to the uterus and significantly decrease fertility. Some of these conditions are even recognized as being associated with ovarian dysfunction (5,11). Reestablishing normal ovarian activity depends on uterine involution (5). Involution disorders cause temporary and/or permanent infertility. Several researchers have proposed models to clarify the effects of the various conditions on reproductive performance (7,12).

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Table I. Lactational incidence of postpartum reproductive problems according to parity in 418 383 lactations from 2000 to 2006

	Parity				Total frequency	
	1	2	3	4+	Total	References
Dystocia (%)	1.3[a]	0.8[b]	0.7[b]	0.8[b]	0.9	2.1[1]
N	1801	816	489	782	3888	
Retained placenta (RP) (%)	3.1[a]	4.1[b]	4.8[c]	5.9[d]	4.3	8.6[2]
N	4256	4374	3461	5839	17 930	
Metritis complex (%)	6.6[a]	5.8[b]	5.8[b]	6.9[c]	6.3	10.1[2]
N	9167	6205	4205	6904	26 481	

[a,b,c,d] Two different letters on the same line indicate a significant difference between the frequencies ($P < 0.05$).

[1] Lactational incidence 39 727 Ayrshire cows in 1993 (22).

[2] Median lactational incidence according to the analysis of several articles published between 1979 and 1995 (23).

The hypothesis of the present study is that uterine problems identified in the first 30 d postpartum as well as increased parity decrease the probability of conception in cows and therefore increase the odds of the cow being categorized as a repeat breeder (RB) and being culled as a result. The key objective of the study is to quantify how reproductive problems that occur during the peripartum period as well as parity affect the odds of a cow being an RB and therefore of being culled. This study investigates the most common peripartum uterine problems: dystocia, retained placenta (RP), and metritis complex.

Materials and methods

A databank of the health records of dairy herds, which was compiled by DS@HR (St-Hyacinthe, Quebec), was used in this study. The databank includes data from approximately 1/3 of the dairy cows in Quebec, most of which are Holsteins. The database represents a total of 448 321 lactations in 2030 herds from 2000 to 2006. The selected herds were served by 59 private veterinary clinics in Quebec. The reproductive data were validated using a herd validation system based on the rate of data recording during reproductive follow-up, which includes veterinary examinations, diseases, and pregnancy diagnosis. This rate represents the proportion of codes in the reproductive sector divided by the number of cows active in a month. Cows on a superovulation protocol and those with a history of < 3 inseminations without reproductive success were excluded from the analysis. The final number of lactations included in this analysis was therefore reduced to 418 383 lactations.

The unit of observation in this study is the health record of each cow for 1 lactation period. Each cow is associated with a herd and a private veterinary clinic. The databank provides parity, number of inseminations, outcome of conception for each artificial insemination (AI — success or failure); presence/absence of dystocia, RP, and metritis complex; and culling data. The cows were categorized as RBs if at least 3 unsuccessful AI attempts were recorded during the same lactation period. Cows that became pregnant after ≤ 3 insemination attempts were included in the "control" group.

The peripartum problems considered for the analysis were dystocia, RP, and metritis complex (9,10). The producers and veterinarians identified the reproductive problems and entered the data into the cow's health record. The data analysis focused on problems within the first 30 d of the cow's lactation. Each condition was reported on the animal health record with the standard codes used in the dairy health records. The category of dystocia includes the peripartum interventions of cesarean section, fetotomy, forced extraction either by a veterinarian or the producer, and observations of abnormal presentation. Dystocia can also result from a fetal abnormality in a normally functioning uterus. When the placental membranes were not expulsed within 24 h of calving, it was considered to be a retained placenta (RP). Metritis complex consists of acute/chronic metritis, endometritis, and purulent discharge, which includes any abnormal discharge that is whitish in color, odorous or not, and located at the vulva or inside the vagina. Such discharge can originate in the uterus, indicating a uterine problem, such as metritis, pyometritis, or endometritis, or it can originate from the vagina, indicating simple vaginitis.

Statistical analysis

Analysis of the descriptive data and statistical analyses were carried out using SAS version 9.1 (SAS Institute, Cary, North Carolina, USA). The initial analysis of co-linearity using the chi-squared (X^2) test found no significant relationships between the variables. A logistic regression was then constructed using the different risk factors as fixed effects and herd as the random effect. It was recognized that there may be clustering of events, both within a farm and within a cow. To address this issue, the same analysis was repeated using MLwiN (University of Bristol, Bristol, UK), with the farm and the ID of the cow within the farm considered as hierarchical levels. This analysis showed that less than 1% of the variation in the total variance occurs at the level of the cow within the farm. It was therefore justified to use only the farm as the random factor in our analysis.

Two different models were analyzed. For the first, the dependent variable was cow status (RB versus control), as defined above (n = 418 383 lactations). The second analysis takes into account the dependent variable — culled versus not culled — on the RB group alone (n = 87 823 lactations). The independent variables are identical for both analyses: presence/absence of the peripartum disorders listed above and parity. All of the peripartum disorders

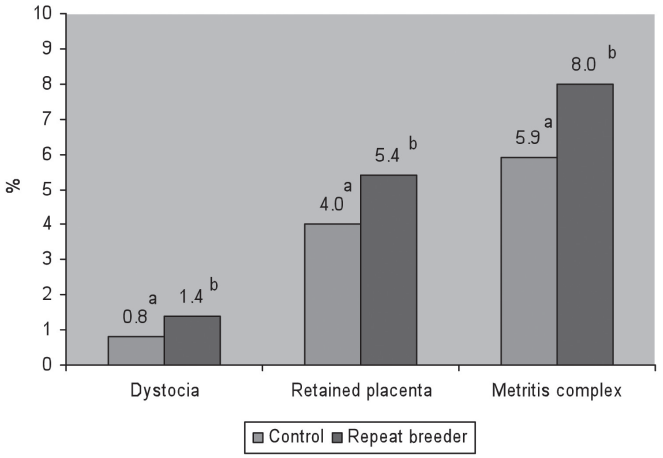

Figure 1. Proportion of control and repeat breeder cows with each postpartum disorder.
[a,b] Proportions labelled with different letters are significantly different ($P < 0.0001$).
Control — Cow that became pregnant in 3 or fewer inseminations.
Repeat breeder (RB) — Cow with at least 3 unsuccessful AI attempts during the same lactation.
Dystocia — Groups together interventions such as cesarean section, fetotomy, forced extraction by the veterinarian or the producer, and observations of abnormal calf presentation.
Retained placenta (RP) — The placental membranes are not expulsed within 24 h after calving.
Metritis complex — Groups together acute/chronic metritis, endometritis, and purulent discharge from the vulva.

are dichotomous variables (0: absent, 1: present). There are 4 levels for parity: 1, 2, 3, and 4+. The effects of each variable were measured using an odds ratio. Contrasts with sequential Bonferroni correction were used to compare the prevalence of peripartum disorders between levels of parity. A significance level of 0.05 was used for all analyses.

Results

The proportion of peripartum disorders for each level of parity is presented in Table I. There is clearly systematic variation based on parity. Comparisons among the different parity groups show that: 1) dystocia was more frequent during first parity; 2) the prevalence of RP increased with parity; and 3) metritis complex was more prevalent in fourth-parity cows. Table I also gives the total lactational incidence of peripartum reproductive disorders in this study as well as that observed in other scientific articles reviewed. Finally, Figure 1 shows the proportion of control and repeat breeder cows with each peripartum disorder.

Table II presents the results of the first analysis, which uses cow status (RB versus control) as the dependent variable and peripartum disorders and parity as the independent variables. The results for a given parity are with respect to the first parity. The analysis shows that the odds of being an RB increased if the cow had a peripartum reproductive problem and also increased with parity. Dystocia had the most negative impact on fertility.

Reproductive inefficiency, or at least RB status, is an important risk factor for culling. Overall, 35% of RB cows were culled compared to only 8% of control cows (Table III). Given these results, it was decided to look at the risk factors affecting culling in the RB group.

Table II. Results of logistic regression model of repeat breeder cows from Quebec database of 418 383 lactations from 2000 to 2006. Odds ratios are present for repeat breeder cows and are classified according to postpartum reproductive problems and parity

	Repeat breeders		
Postpartum problem[a]	Odds ratio	Confidence interval	*P*-value
Dystocia	1.44	1.37 to 1.51	< 0.0001
Repeat breeder (RB)	1.13	1.10 to 1.17	< 0.0001
Metritis complex	1.22	1.19 to 1.25	< 0.0001
Parity[b]			
2	1.18	1.16 to 1.20	< 0.0001
3	1.24	1.21 to 1.26	< 0.0001
4+	1.42	1.39 to 1.45	< 0.0001

Multivariate analysis with herd as the random effect.
Dependent variable of interest — Status of cow (repeat breeder versus control).
[a] Effect of postpartum problem (presence versus absence).
[b] Effect of lactation with respect to the first lactation.
Repeat breeder (RB) — Cow with at least 3 unsuccessful AI attempts during 1 lactation.

The culling decision during lactation was used as the dependent variable and the same risk factors as those for the first analysis were entered and tested in the new model. Odds ratios for culling are presented in Table IV. Peripartum reproductive events and parity were risk factors for culling after more than 3 inseminations. Uterine disorders early in the lactation did not seem to have a great impact on the final verdict. However, parity greatly affected the decision to cull a cow.

Discussion

The findings of the present study on the prevalence and potential impact of dystocia are similar to the results of previous studies. Although dystocia is rare, it greatly influences future outcomes in terms of reproduction and/or culling (7). The underlying causes of this disorder may include uterine inertia (13), contamination of the reproductive system following obstetrical manipulations (8), stress and pain caused by this event (5,14), and impairment of uterine involution.

The delay in uterine involution caused by dystocia, RP, and the metritis complex influences to some degree the pulsatile secretion of luteinizing hormone (LH) and the lifespan of the corpus luteum (14). Micro-organisms in the uterus, uterine trauma, and/or an inadequate peripartum immune system are all associated with a delay in uterine involution (8).

While retained placenta (RP) and metritis have less impact on repeat breeder status, there are 2 reasons they should not be neglected. The first is that a retained placenta increases the risk of developing metritis (15). The present finding demonstrated that 29% of cases of retained placenta were followed by metritis complex. This is in agreement with the results of another study that found that 25% to 50% of retained placentas were associated with metritis (16). The

Table III. Proportion of culling (%) for control and repeat breeder cows from Quebec database of 418 383 lactations from 2000 to 2006

	Control	Repeat breeder (RB)
Not culled	303 743	56 901
	91.9%[a]	64.8%[a]
Culled	26 817	30 922
	8.1%[a]	35.2%[a]

[a] Percentage calculated by column.

Control — Cow that became pregnant in 3 or fewer inseminations.

Repeat breeder (RB) — Cow with at least 3 unsuccessful AI attempts during 1 lactation.

Table IV. Logistic regression showing effect of postpartum reproductive problems and parity on culling for the group of repeat breeder cows (N = 87 823 RB cows) from Quebec database from 2000 to 2006

	Culled cows		
Postpartum problem[a]	Odds ratio	Confidence interval	*P*-value
Dystocia	1.12	1.04 to 1.21	0.0018
Retained placenta (RP)	1.07	1.03 to 1.11	0.0002
Metritis complex	1.10	1.07 to 1.14	< 0.0001
Parity[b]			
2	1.24	1.20 to 1.28	< 0.0001
3	1.39	1.35 to 1.43	< 0.0001
4+	1.67	1.62 to 1.71	< 0.0001

Multivariate analysis with herd as the random effect.

[a] Effect of postpartum problem (presence versus absence).

[b] Effect of lactation with respect to the first lactation.

Dependent variable of interest — Status of cow (repeat breeder versus control).

RB (repeat breeder) — Cow with at least 3 unsuccessful AI attempts during 1 lactation.

second reason is that the lactational incidence of metritis complex is greater than that of dystocia. Considering its greater incidence and its effect on reproduction (RB categorization), generally speaking metritis complex is actually more problematic than dystocia.

As mentioned previously, uterine insults such as dystocia, RP, metritis complex, and endometritis are clearly related to decreased fertility in cows. Despite the association between peripartum disorders and RB, however, many cows not exposed to peripartum uterine conditions during early parity also ended up in the RB group. It is clear that the repeat breeder syndrome is not just associated with peripartum disorders. Based on the present study, there is a high baseline risk of cows becoming repeat breeders if they are not exposed to peripartum reproductive disorders: 20.4% of cows (76 715/376 307) with no peripartum reproductive disorders became RB as opposed to 26.4% of cows (11 108/42 076) with peripartum reproductive disorders. Given that the overall lactational incidence of peripartum disorders is 10%, the population attributable risk (PAR) for RB cows associated with uterine disorders is only 0.6% [(26.4% − 20.4%) × 10%].

Clearly, there are other risk factors that influence a cow's reproductive prognosis. In addition to uterine abnormalities, metabolic pathologies, such as milk fever and ketosis, and ovarian pathologies can also disturb the cow's normal fertility. Such pathologies (for example, cysts) may, through various mechanisms, limit the number of estrous cycles before the recommended insemination period. These processes have a negative impact on reproductive indices such as the interval between calving and first insemination, the chance of conception during first breeding, the interval between calving and successful insemination, and the number of inseminations (17,18). All these conditions, as well as external factors such as management strategies, represent confounding factors in the present study.

In terms of prevention, it appears that the absence of postpartum uterine disorders in the entire population of dairy cows in Quebec would decrease the absolute odds of a cow becoming a repeat breeder by only 0.6% (population-attributable risk). When trying to understand the problem of repeat breeding, risk factors other than peripartum uterine conditions clearly need to be considered.

The results concerning parity are not surprising. The factors affecting reproduction in cows of greater parity include increased milk production (3), negative energy balance (3), embryonic mortality (19), and the incidence of reproductive disorders such as metritis (5,20). There is currently little information on the relationship between milk production and fertility, the pathophysiology of postpartum disorders, and the aging of the reproductive tract and its capacity to support embryonic establishment.

The most important reason for culling dairy cows is reproduction problems (21). Peripartum disorders and an increase in parity, however, are associated with inferior reproductive performance, which in turn increases the odds of a cow being categorized as a repeat breeder (RB) and thus indirectly increases the odds of a cow being culled. The relationship between peripartum disorders and culling is primarily mediated by RB status. Parity, however, remains an important risk factor for culling in RB cows. The aging of cows and their reproductive systems probably involves more complex and permanent uterine changes than the effect of peripartum disorders alone. Furthermore, an increase in parity not only brings reproductive problems but also leads to serious locomotive, mammary, and metabolic disorders, an effect that could confound our results.

While "repeat breeder" came into use many years ago at a time when production methods were very different from today (2009), the term is still used in infertility analyses such as in this article. The term is not precise and does not necessarily imply a pathological condition in the cow. For dairy cows, the length of time of reproductive inactivity (days open) is more of an identifier of reproductive problems than is the number of AIs per se. In Quebec, however, with a voluntary waiting period of 60 d in milk (DIM) and an interval between AIs of approximately 40 DIM, the repeat breeder is considered non-gestating at ± 140 DIM, which is considered a problem cow in terms of reproduction.

Limitations of the study

The lactational incidence of peripartum reproductive disorders reported in this study suffers from the limitations inherent in retrospective observational studies. It is difficult to compare these results with those of other scientific studies for the following reasons: the

diagnostic methods used in studies are not identified, the definitions of reproductive conditions vary, the postpartum period targeted varies, and the genetic criteria used to identify the cow population varies. The data suffer from a lack of precision, as is often the case with observational retrospective studies. This limitation is due primarily to the diversity of observers. To simplify matters and avoid confusion related to diagnosis, however, the study combines 3 postpartum disorders into the metritis complex: metritis (acute/chronic), endometritis, and purulent discharge. In addition to endometritis, cows with obvious reproductive disorders such as acute and chronic metritis should have been noted and included in the analysis. Cases of purulent discharges were also considered to be part of the complex, including all cases when producers suspected infection or inflammation of the reproductive tract, without confirmation and diagnosis by a veterinarian.

Given the above limitations and the fact that peripartum reproductive disorders may be underrepresented in the databank, the study may underestimate the differences in the reproductive performance of cows with and without reproductive problems.

In conclusion, postpartum uterine status is critical for determining a cow's reproduction status and, indirectly, its survival in the herd. The results of the present study show that peripartum reproductive disorders decrease the fertility of dairy cows and increase their odds of requiring multiple inseminations (4 and more) and eventually being culled. Despite the importance of the effects of dystocia, RP, and metritis complex to reproduction, there were in fact many cows in the repeat breeder group that did not have peripartum uterine disorders. The other causes of repeat breeding therefore need to be investigated. Finally, parity number is an important risk factor for a cow to be categorized as a repeat breeder and possibly being culled. A variety of factors associated with advanced age are also associated with reproductive inefficiency and involuntary culling.

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Références

1. McDougall S. Reproduction performance and management of dairy cattle. J Reprod Dev 2006;52(1):185–194.
2. Royal MD, Darwash AO, Flint APF, Webb R, Wooliams JA, Lamming GE. Declining fertility in dairy cattle: Changes in traditional and endocrine parameters of fertility. Animal Science 2000;70:487–501.
3. Lucy MC. Reproductive loss in high-producing dairy cattle: Where will it end? J Dairy Sci 2001;84(6):1277–1293.
4. Levine HD. The Repeat Breeder Cow. Bovine Practioner 1999; 33:97–105.
5. Opsomer G, Grohn YT, Hertl J, Coryn M, Deluyker H, de Kruif A. Risk factors for post partum ovarian dysfunction in high producing dairy cows in Belgium: A field study. Theriogenology 2000;53(4):841–857.
6. Coleman DA, Thayne WV, Dailey RA. Factors affecting reproductive performance of dairy cows. J Dairy Sci 1985;68(7): 1793–1803.
7. Erb HN, Smith RD, Oltenacu PA, et al. Path model of reproductive disorders and performance, milk fever, mastitis, milk yield, and culling in Holstein cows. J Dairy Sci 1985;68(12):3337–3349.
8. Bell MJ, Roberts DJ. The impact of uterine infection on a dairy cow's performance. Theriogenology 2007;68(7):1074–1079.
9. Erb HN, Martin SW. Age, breed and seasonal patterns in the occurrence of ten dairy cow diseases: A case control study. Can J Comp Med 1978;42(1):1–9.
10. Sandals WC, Curtis RA, Cote JF, Martin SW. The effect of retained placenta and metritis complex on reproductive performance in dairy cattle — a case control study. Can Vet J 1979;20(5):131–135.
11. Williams EJ, Fischer DP, Noakes DE, et al. The relationship between uterine pathogen growth density and ovarian function in the postpartum dairy cow. Theriogenology 2007;68(4):549–559.
12. Correa MT, Erb H, Scarlett J. Path analysis for seven postpartum disorders of Holstein cows. J Dairy Sci 1993;76(5):1305–1312.
13. Ball PJH, Peters AR. Reproduction in cattle. 3rd ed. Oxford, UK: Blackwell Pub., 2004:vi, 242.
14. Butler WR, Smith RD. Interrelationships between energy balance and postpartum reproductive function in dairy cattle. J Dairy Sci 1989;72(3):767–783.
15. Laven RA, Peters AR. Bovine retained placenta: Aetiology, pathogenesis and economic loss. Vet Rec 1996;139(19):465–471.
16. LeBlanc SJ. Postpartum uterine disease and dairy herd reproductive performance: A review. Vet J 2008;176(1):102–114.
17. Butler WR. Nutritional interactions with reproductive performance in dairy cattle. Anim Reprod Sci 2000;60–61:449–457.
18. Vanholder T, Opsomer G, de Kruif A. Aetiology and pathogenesis of cystic ovarian follicles in dairy cattle: A review. Reprod Nutr Dev 2006;46(2):105–119.
19. Ball PJ. The relationship of age and stage of gestation to the incidence of embryo death in dairy cattle. Res Vet Sci 1978;25(1): 120–122.
20. LeBlanc SJ, Duffield TF, Leslie KE, et al. Defining and diagnosing postpartum clinical endometritis and its impact on reproductive performance in dairy cows. J Dairy Sci 2002;85(9):2223–2236.
21. Gröhn YT, Rajala-Schultz PJ. Epidemiology of reproductive performance in dairy cows. Anim Reprod Sci 2000;60–61:605–614.
22. Rajala PJ, Grohn YT. Disease occurrence and risk factor analysis in Finnish Ayrshire cows. Acta Vet Scand 1998;39(1):1–13.
23. Kelton DF, Lissemore KD, Martin RE. Recommendations for recording and calculating the incidence of selected clinical diseases of dairy cattle. J Dairy Sci 1998;81(9):2502–2509.